Effects of land use on intermediate snail host fauna, abundance, distribution and cercariae infection rate in Omo-Gibe river basin, Ethiopia

Ketema Deribew (ketemader@gmail.com)
Jimma University College of Public Health and Medical Sciences
Etana Jaleta
Jimma University Department of Environmental Science and Technology
Belayhun Mandefro
Jimma University Department of Environmental science and Technology
Zeleke Mekonnen
Jimma University School of Medical Laboratory Science
Delenasaw Yewhalaw
Jimma University Tropical and Infectious Disease Research center
Yihun Abdie
Jimma University Department of Environmental Science and Technology
Seid Tiku Mereta
Jimma University Department of Environmental science and Technology

Research

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Abstract

Background: Land use and land cover change significantly affects biodiversity, abundance and distribution of intermediate snail host fauna. In Omo-Gibe river basin the extent of land-use change is high due to anthropogenic activities leading to habitat change of freshwater snail intermediate hosts. Most intermediate snail hosts of human Schistosome parasites belong to two genera, *Biomphalaria* and *Bulinus*. In Addition, *Lymnea* spp. is another important host of Fasciola which causes fasciolasis in domestic animals and human. This study aims to assess the effects of land-use on the distribution and abundance of freshwater snail intermediate hosts and cercariae infection rates of fresh water intermediate snail hosts in Omo-Gibe River basin, Ethiopia.

Methods: This study was conducted in Omo-Gibe river basin in 130 sampling sites which include rivers, lakes, dams, stream, wetlands and irrigation ditches. At each site data on land use, anthropogenic activities, freshwater snail abundance and species diversity, and water samples were collected. Snails were collected from each sampling sites using a scoop (20cm x 30cm) with a mesh size of 300µm. Snails were sorted by genus on Enamel pan using forceps and preserved in labeled vials containing 75% ethanol. Live snails collected from the same habitat were sorted carefully and put in clean plastic buckets half filled with water. Afterwards, snails were provided with fresh lettuce leaves and maintained in the laboratory. Snails were then identified morphologically to family, genus and to species level. Each snail was examined for cercaria shedding by placing in a petri dish containing water and exposed to the sun for 2 hours. Cercariae were morphologically identified by microscopy. ArcGIS software of version 10.3.1 was used to map snail distribution and data were analysed using SPSS version-20.

Results: The results obtained in this study shows clearly that land use change affect the distribution and abundance of fresh water snails in Omo-Gibe river basin. Fresh water snails were more abundant in farmland and settlement areas. Of the total 2,559 freshwater snails collected from 130 surveyed sites in Omo-Gibe river basin, 1749 (68.34%) belongs to medically important snail species. *Biomphalaria spp.914 (35.7%),, Lymnea spp.439 (17.1%),, Physa spp.* 343(13.4%) and *Bulinus spp 53 (2%))*. *Sphaeriidae* group accounted for 810 (31.6%) of the collected specimens. *Biomphalaria pfeifferi* was the predominant species of the total snail sampled from lakes, wetlands, rivers and irrigation ditches. *Biomphalaria pfeifferi* was the most infected snail species by different cercariae. *Bulinus globosus* and *L.natalensis* were infected by more than one and same type of cercariae. However, none of *B. sudanica and P. acuta* specimens was infected by trematode.

Conclusions: The results of this study revealed that land use change altered the abundance, distribution and diversity of medically important fresh water snails in the study area. In general medically important freshwater snails which include: *Biomphalaria spp, Bulinus spp and Lymnaea spp* were collected from lakes, rivers, wetlands, irrigation ditches.. The medically important snail species found infected by cercaria are *L. natalensis*, *B. pfeifferi* and *B. globosus*. *Biomphalaria pfefferi* was the predominant species and highly infected by cercariae. Higher infection rate was observed in snails collected in Farmland (16.59%) and Grassland (36.6%).

Background

The land-use concept has evolved during recent decades and it is now considered as the socioeconomic function of land. It is recognized that the terms of these land categories are a mixture of land cover (e.g., Forest land, Grassland, Wetlands) and land-use (e.g. Cropland, Settlements) [1]. Land-use changes are complex and interrelated expansion of one land use type at the expense of others [2]. The major land-use changes are conversion of woodlands to cropland [3]. Due to the increase of human population and changes in land use, the freshwater ecosystems are under constant pressure [4].].Study by Abate and Lemenih [5] in Omo-Gibe watershed reported that land-use/land-cover must be improved in order to manage natural resources and conserving of the existing vegetation. The study by Gonzalez *et al* [6] indicated that the main direct drivers of tropical deforestation are agricultural expansion, high levels of wood extraction, and the extension of roads and other infrastructure into forested areas. Land use and cover changes seem to be a common physical factor that impacts fresh water snail distribution and diversity [7, 8]. Bagalwa *et al* [9] reported that land use and land cover changes affect the distribution of snail. There is positive correlation between snail richness and built-up area class [9]. Gabriel *et al* [10] also reported activities associated with agricultural irrigation can cause adverse impacts on wetland ecological resources. Land-use change due to human settlement and his domesticated animals can affect water quality [11]. Gebresenbet [12] also indicated that forests and vegetation have been cleared in Omo-Gibe river basin, southwest Ethiopia through increased human activities and regional growth to urbanization. Study by Abate and Lemenih [5] also confirmed that agricultural activities increased the whole periods in Omo-Gibe river basin.

A number of studies have shown marked changes in chemical water quality associated with land use and land cover change [13]. Physico-chemical parameters of water bodies could influence the abundance and distribution of snail intermediate host [14]. Comprehensive investigation of the role of anthropogenic factors on snail diversity patterns could probably contribute to a better understanding and management of problems associated with potential disease as well as snail conservation. Report by WHO [15] showed large water bodies such as lakes, rivers, irrigated lands, and dams are also key for schistosomiasis transmission and epidemiology, particularly in Africa. Different surveys and studies showed the changes in invasion of freshwater snail intermediate hosts in Ethiopia. Some of the freshwater snail species are medically important. They are intermediate hosts for a number of trematodes. The trematodes rely on specific species of snails to complete their life cycle; hence the ecology of the snail is a key element in transmission of schistosomiasis [16]. Schistosomiasis is a disease caused by infection with schistosome parasites [17].The epidemiology of schistosomiasis and its intermediate snail host in Ethiopia is well documented. However, new snail foci and infectious areas have been discovered in different parts of the country mainly due to land-use changes. In Ethiopia the prevalence of human schistosomiasis has been known to be endemic and causes substantial public health and socio-economic impact [18]. The current agricultural and water resource development activity in Awash Valley is a witness for transmission intensification or the introduction of diseases into previously non-endemic areas [19].

Different studies conducted in Ethiopia showed that Omo-Gibe river basin also changed due to human activities. This change may affect the intermediate snail hosts distribution. Land-use maps at lower Omo-Gibe flood plains showed that the area under cultivation or agriculture, including recession agriculture, was around 3, 738ha [20]. Diseases and the agents causing them are spatially and temporally distributed and geo databases integrating data from multiple sets of information are managed within the frame of GIS to identify the disease cluster and distribution [21]. Simoonga *et al* [22] indicated the use of remote sensing (RS) and GIS have been instrumental for identification and mapping of high-risk areas of Omo-Gibe river basin in order to prioritize national schistosomiasis control programs.

Trematodes require one definitive host and one or two intermediate hosts to complete their life cycle. In these hosts, the trematode passes through different development stages, including the adult, egg and various larval stages, such as the miracidium, cercaria and others. One of the hosts of these trematodes is almost always a snail that acts as an intermediate host, in which the cercaria stage is developed. Eggs are eliminated with feces or urine under optimal condition hatch in to miracidia which swim and penetrate specific snail intermediate hosts develop to cercaria .The infective cercaria leaves the snail host to water and swims around till it finds the next host in its life cycle . The proportion of snails that release cercariae (prevalence of infection) and the number of cercariae released from each infected snail (intensity of infection) play important roles in the transmission of trematodes from the snail host. In Omo-Gibe river basin, types of trematode cercaria, the host snail distribution and prevalence of snails infected by trematode cercaria are not well studied and documented .Numerous studies conducted in different localities of Ethiopia mainly deal with the prevalence of *S. mansoni* infection and its control. Yet, its endemicity has long been established and new foci have also been continuously reported [18]. Still information on the environmental factors affecting the distribution and abundance of freshwater snail intermediate host and schistosomiasis infection prevalence is limited. Spatial risk mapping basically indicate the suitability of an area for the emergence and distribution of the intermediate freshwater snail hosts and the prevalence of schistosomiasis. Therefore, this study aims to determine the effects of land-use type on the distribution of freshwater snail intermediate hosts and snail intermediate host infected with different trematode cercariae infection in Omo-Gibe River basin, Ethiopia.

Methods

Study Area

The study was carried out in Omo-Gibe river basin, Southwest Ethiopia. The area extends from 4°25'51.611"N to 9°22'28.047"N and from 34°57'7.941"E to 38°24'42.242"E. It has a total area of 7,956,121.3 hectare. The area is located at an altitude ranging from 299 to 3851 m.a.s.l. It has three Agro-ecological zones such as arid and semi-arid (Kolla), semi-humid (Weyna Dega), and cool and humid (Dega). The river basin has a total length of 760km, and annual water volume of 17.96 BMC *(Billion Metric Cube)*. One of the areas under the basin is Chebera-Churchura National Park which is located within Dawro district and in Konta special district. The park is located in South West region of Ethiopia and 580 km from Addis Ababa. It covers an area of 125,000 hectare and lies between 36°27'00" - 36°57'14" E longitude and 6°56'05" - 7°08'02" N latitude. It is located at the center of Omo-Gibe River Basin with two main crater lakes, Bulo (koka) and Keribela. The other areas of the sampling lies in Oromia Regional state, Jimma Zone, Gilgel-Gibe tributaries.

Study design

A cross-sectional study was employed from February to May 2016, during the dry season to determine and map the effect of Land use on the distribution of freshwater snail intermediate hosts in Omo-Gibe river basin, southwest of Ethiopia.

Sample Site selection

Sample sites were selected based on the results of preliminary survey from irrigation canals, dams, mining, washing, grazing, and farming. The sampling site included: Lake Koka and Keribela (ten sampling stations), Rivers (Ninety-four sampling stations), Wetlands (Twenty-two sampling stations), Irrigation ditches (Two sampling stations) and Dams (Two sampling stations). In total 130 sampling sites were selected and surveyed.

Snail Collection, identification and cercaria shedding

Snails were collected from 130 sampling sites from February to May, 2016. At each site data on land use, with their coordinates and anthropogenic activities were collected. Freshwater snails and water samples were collected. Snails were collected from each sampling sites using a scoop (20 x 30cm) with a mesh size of 300μm. Each collection entails a 10-minute kick sampling at a radius of 10 meters. Time was allotted proportionally to cover different meso-habitats such as open water and emergent vegetation. The bottom sediment was disturbed by foot during sampling in order to collect the benthic macroinvertebrates. Also the macroinvertebrates data were collected using a D frame net from different habitat types (rifle, pool and open water emergent vegetation) based on the sample processing protocol Stark, *et al* [23]. Snails were sorted on Enamel pan using Forceps and stored in vials containing (75% ethanol) and labeled for morphological identification. Live snails were sorted carefully by hand and put in clean plastic buckets half filled with water from the same habitat and labeled in the field. Then, snails were maintained and fed with fresh lettuce leaves and identified to family and when possible to species using a stereomicroscope (10 x magnifications) and the taxonomic identification keys of Oscoz *et al* [24]. Each snail was examined for cercariae shedding by placing in a petri dish containing 10 ml water exposed to light for 2 hours. Snails that did not shed cercariae in the first hour were monitored for shedding cercariae at one hour intervals for another 24 hours. Snails that did not shed cercariae on the first exposure were kept in glass aquaria in the laboratory and rechecked for cercariae shedding for four weeks. Prevalence of snail infection was determined as a percentage, by taking the number of snails that released cercariae divided by the total number of snails collected from a particular site exposed to shed cercaria. Cercariae were morphologically identified by using microscope and both cercariae and snails were preserved in ethanol.

Water Quality Analysis

To see variations in water quality due to land-use change, a number of environmental parameters were recorded during the study. Chemical pollution was a factor in most streams so that the major chemical pollutants (i.e. the physico-chemical parameter) were recorded. Temperature (^0C), conductivity ($\mu S.cm^{-1}$), pH, dissolved oxygen saturation (DO %), dissolved oxygen concentration DO (mg/L), turbidity (NTU) and transparency (cm) were measured onsite at each sampling location. Water from each sampling sites was collected using a thoroughly rinsed one-liter volume materials (1000 mL sizes of PVC plastic bottles) and taken to the laboratory of Department of Environmental Health Sciences and Technology of Jimma University. Water samples were kept deep freezer for further analysis of total Hardness (TH), biochemical oxygen demand (BOD_5), orthophosphate(PO_4^{3-}), total suspended solids (TSS)), Electrical conductivity (EC) and nitrate (NO_3^-) concentration. The water channel width, water depth, flow velocity, riparian vegetation, canopy cover, and water sinuosity were estimated following the method described by Barbour *et al* [25].

Data Analysis

Coordinate readings (Latitude, Longitude) were recorded using hand-held GPS unit from the sampling sites and had been converted to UTM and entered to Microsoft Excel. Then the data that entered to Excel was verified and converted to shape file using ArcGIS software version 10.3.1 and utilized for mapping of freshwater snail species distribution, freshwater snail species density and cercaria infected freshwater snail species. SPSS version 20.0 was used for analysis of data. Descriptive statistics, analysis of variance (ANOVA) was applied for data analysis. P-values were considered statistically significant when less than 0.05.

Results

Abundance and Distribution of Freshwater intermediate snail hosts

A total of 2,559 freshwater snail specimens were collected from 130 different sampling sites. Among this, 1749 were medically important snail species which includes: Biomphalaria pfeifferi(906),Biomphalaria sudanica (8), Bulinus globosus (53), Lymnea natalensis(421) and Lymnea truncatula (18). Other intermediate host that are not medically important recorded during the survey were Physa acuta (336) and Physa spp (7). Biomphalaria pfeifferi was the predominant snail species of the total snail collection. It was highly abundant in rivers. Lymnea natalensis was the second predominant snail species collected. As shown in table 1, fresh water snails are not found from dam reservoir shores habitat type. The least fresh water snail species collected were L. truncatula and B. sudanica. The number of snails collected in different habitat is highly varied: Lake habitat (71), Wetland (1291), river (11740), Irrigation ditches (23) and dams (0).Higher number of snails were collected in wetland and lower number in irrigation ditches.

Table 1: Abundance and distribution of freshwater snails recorded from different habitats in Omo-Gibe river basin, Ethiopia

Fresh water Snails	Habitat abundance					Total
	Lake	Wetland	River	Dam	Irrigation ditch	
15	*Lymnea natalensis*	293	104	-	9	421
Lymnea truncatula	-	-	18	-	-	18
Physa acuta	-	281	55	-	-	336
Physa. spp.	-	7	-	-	-	7
Biomphalaria pfeifferi	26	58	808	-	14	914
Biomphalaria sudanica	8	-	-	-	-	8
Bulinus globosus	22	22	9	-	-	53
Sphaeriidae	-	630	180	-	-	810
Total	71	1291	1174	-	23	2,559

Land-use type and environmental factors

Table 2 shows land-use patterns and environmental factors in Omo-Gibe river basin. Mean water flow velocity was highest at Woodland with (Mean=0.67) and the least was recorded at Grassland areas with (Mean=0.19). On the other hand the highest mean water depth was recorded from Settlement areas with (Mean=0.49). Canopy cover and vegetation cover were comparatively higher in Forest areas.

Table 2**: Land-use type and environmental factors in Omo-Gibe river basin, Ethiopia.**

Land-use Type	Flow Velocity (m/s)(M±SE)	Water depth (m) (M±SE)	Canopy cover (%) (M±SE)	Vegetation cover(%) (M±SE)
Forest	0.2±0.25	0.3±0.24	75.23±23.58	1.00±0
Shrubs land	0.29±0.36	0.38±0.23	14.21±16.01	0.53±0.513
Grassland	0.19±0.23	0.38±0.26	18.07±24.92	0.63±0.492
Farmland	0.32±0.3	0.31±0.25	28.13±24.72	0.28±0.457
Woodland	0.67±0.31	0.24±0.11	40.5±27.02	1±0
Settlement	0.26±0.27	0.49±0.4	22.5±19.75	0.45±0.51

There is significance association between land-use types with flow velocity (p=0.001) and canopy cover (p=000). Post Hoc mean comparison Tukey test shows higher mean water flow velocity in woodland (p=0.001). The canopy cover in all types of land-use type is significantly different. Except with Forest areas, water depth and vegetation cover of the sampling sites have no significance difference. Vegetation cover, among 130 sampling sites observed, existed in 75 sampling sites. This roughly accounts for about 59.2%.The majority of vegetation cover is located in forest (16.9%) and grassland (13.1%) areas.

Water quality analysis and abundance of nail in relation to land-use types

The water chemical content was analyzed for all 130 sampling sites in relation to land-use types. The highest pH value (M=8.46) was recorded in water bodies of settlement areas (range 5.3± 6.5 to 7.8 ± 6.5). However, least pH mean value (M=6.87) was recorded in Shrub land (range 6.28±0.36 to 7.40±0.36). The dissolved oxygen saturation (DO %) was highest in Forest areas with mean percentage (M=83%). Whereas the mean percentage of DO (49.6%) was recorded from settlement area. The water dissolved oxygen concentration (DO mg/L) was highest in Settlement areas with mean value (M=21.2 mg/L). The least mean value of DO (M=3.87 mg/L) was recorded in Shrubland areas. The nitrate concentration (NO3- mg/L) of the water was highest (M=6.04 mg/L) in Settlement area while the least mean value (M=0.57 mg/L) was recorded in Forest area .The highest mean value (59.55 mg/L) of total hardness (TH mg/L) was recorded in Forest area while the least mean value (23.80 mg/L) was observed in Woodland area. The five days biochemical oxygen demand (BOD5 mg/L) was highest (14.11 mg/L) in Shrubs land while the least mean value was recorded (11.59 mg/L) in Settlement area.

Table 3: Results of water quality analysis in different land-use types in Omo-Gibe river basin, Ethiopia.

		Land-use type					
		Forest	Shrubsland	Grassland	Farmland	Woodland	Settlement
Water quality parameters (Mean±SE)	pH	7.64±0.19	6.87±0.08	7.04±0.14	7.35±0.08	7.18±0.16	8.46±1.17
	DO%	83.21±14.29	55.20±2.65	58.58±3.24	62.39±2.27	68.04±1.40	49.57±3.49
	DO(mg/L)	4.68±0.23	3.87±0.19	3.92±0.21	6.50±2.16	4.94±0.09	21.20±17.46
	EC (µS/cm)	233.64±25.79	125.37±12.04	272.12±113.9	182.21±13.89	126.20±19.0	231.47±31.52
	PO_4^{3-}(mg/L)	0.20±0.05	0.20±0.05	0.16±0.06	0.24±0.04	0.23±0.08	3.26±2.88
	TH (mg/L)	59.55±6.84	29.79±4.12	40.62±7.39	43.58±5.19	23.80±7.26	43.22±5.25
	NO_3^-(mg/L)	0.57±0.12	1.00±0.31	0.93±0.29	1.08±0.20	1.10±0.33	6.04±2.62
	BOD(mg/L)	13.89±1.04	14.11±0.96	11.94±0.97	13.02±0.68	11.65±1.57	11.59±1.42
	COD(mg/L)	20.83±1.55	21.16±1.44	17.91±1.46	19.52±1.02	17.48±2.35	17.39±2.13

Water quality analysis with land-use types shows significance differences in PH (p=0.02), total hardness (p = 0.001) and electric conductivity (P=0.000). Tukey HSD test show that there is significance difference in PH between grassland and shurub land (p= 0.042) and grass land with settlement (p=0.012).The electrical conductivity difference between forest and farmland (p=0.001), farmland and grassland (p=0.002) was significant. The Post hoc multiple comparison (Tukey test) shows significant difference between farmland and forest (p=0.000) and grassland (p=0.001).

Distribution and abundance of freshwater snails in relation to land-use type

In a total of 130 sampling sites, *Biomphalaria pfeifferi* was collected from 14 sites of Farmland followed from 12 sites of Settlement land-use types. The total freshwater snail species was collected from 51 sampling sites of all land-use types except woodland. *B. globosus* was collected in 8 sites of forest land-use type followed by 5 sites in Settlement sampling sites. However, it was not found at 108 sampling sites of different land use type. *L. natalensis* was collected from a total of 38 sampling sites of different land-use types. This snail species was not observed in 92 sampling sites. The distribution of *L. truncatula* was observed at seven sampling sites and this snail species was not found at 123 sampling sites except in Forest and Shrub land. *B. sudanica* was collected from 2 sampling sites at the Forest and not found at 128 sampling sites of all land-use types.

Table 4**: Distribution of freshwater snail in different land use type in Omo-Gibe river basin, Ethiopia.**

Land-use Type	No. of sampling sites	Freshwater Snails							
		L.natalensis	*L.truncatula*	*P.acuta*	*Physa.spp*	*B.pfeifferi*	*B.sudanica*	*B.globosus*	*Sphaeriidae*
Forest	22	31	-	-	-	28	8	22	27
Shrubsland	19	20	-	13	-	72	-	4	106
Grassland	27	26	1	63	1	114	-	10	26
Farmland	32	31	12	10	6	407	-	8	49
Woodland	10	1	2	-	-	-	-	-	77
settlement	20	312	3	250	-	285	-	9	525
Total	130	421	18	336	7	906	8	53	810

Among these freshwater snail collected, the majority of snail species, 1384 (54 %) were collected from Settlement area followed by Farmland land-use type 523 (20.4 %). Higher abundance of snails collected in settlement area (p=0.001) compared to non-settlement areas. The Post Hoc multiple comparison Tukey test shows that the abundance of nail is higher in Farmland compared to forest, Shrubland, grass land and wood land (p=0.04).The least number of freshwater snail species was 80 (3.1 %) collected from Woodland land-use type.

The distribution of freshwater snail species in different land-use types is shown in Figure 3. L.natalensis (n=312) and P. acuta (n=250) are more abundant freshwater snails in Settlement land-use type. The abundance of B. pfeifferi (n=407) is higher in Farmland land-use type. Though medically not important, the highest distribution of Sphaeriidae was collected in settlement land-use type.

Distribution of cercariae infected snails and infection rate

All collected freshwater snails were tested for trematode cercaria infection. The cercariae positive freshwater snail intermediate hosts were recorded from eleven sites of the surveyed land-use types. The numbers of cercaria infected snails are 14, 40, 49 and 6 in Settlement area, Grassland, Farmland and Shrubs land respectively. The medically important snail species found infected by cercaria are L. natalensis, B. pfeifferi and B. globosus. Higher infection rate was observed in snails collected in Farmland (16.59%) and Grassland (36.6%). There is no significant association between cercariae infection rate and land-use (p = 0.29). The overall cercaria infection rate was 4,25%.

Table 5: The number of cercarial positive freshwater snail in the study area.

Land-use type	No of snails collected	Number of cercariae infected snails	Infection rate (%)
Settlement	1384	14	1.01
Grassland	241	40	16.59
Farmland	523	49	9.36
Shrubland	215	6	2.79
Forest	116	0	0
Woodland	80	0	0
Total	2559	109	4.25

Bimphalaria pfeifferi was the most infected snail species by different types of cercariae. B.globosus and L.natalensis was also infected by 2 and 3 types of cercariae respectively. However, none of B. sudanica and P. acuta specimens was found infected by trematode cercariae.

Table 6: Frequency of freshwater snail species positive for cercariae infection recorded in Omo-Gibe river basin, Ethiopia.

Snail species	No Infected snails	Type of cercariae							
		Echinostome	BAD	BAM	Amphistome	Xiphidiocercariae	Metacercariae	Un-fur cer	Un-sing cer
B .pfeifferi	95	28	39	1	19	0	5	2	1
B. globosus	5	3	0	0	2	0	0	0	0
L .natalensis	11	7	0	0	0	3	0	1	0
Total	109	38	39	1	21	3	5	3	1

(BAD) = *Brivifurcate apharyngeate diastome* cercariae, (BAM) = *Brivifurcate apharyngeate monostome* cercariae, (Un-fur cer) = *Un-identified furcocercous* cercariae *(*Un-sing cer.) = *Un-identified single tail cercariae* types.

The distribution of cercariae infected snails in different land use type is shown in figure 4. The B. pfeifferi and B. globosus were positive for cercariae which were collected from cultivated land; rainfed, cereal land cover system; lightly stocked and moderately stocked land-use type. Biomphalaria pfeifferi was also found in Grassland moderately stocked land-use type with L. truncatula. Whereas, L. natalensis was recorded from settlement and cultivated land-use types.

Discussion

This study shows *B.pfeifferi* was the predominant freshwater snail (35.4%) of the total snail collected in 130 sites. It was encountered in all sampled habitats except Dam. This study agreed with similar findings [26], depth of dam is one of cause for reduction of fresh water snail. Fish predators and unconducive temperature are also cause for reduction of fresh water snail [27].The highest prevalence of B*. pfeifferi* (89.2%) was recorded from river habitats. The studies of De Kock [28] shows, B. pfeifferi present in different water-bodies, but the highest percentages were recovered from rivers. The freshwater snail abundance varied significantly from one site to the other was agreed by Njoku-Tony [14].The other medically important snails collected was *L.natalensis* and is second dominant and abundant species. Moreover, studies of Gabriel *et al* [10] showed that *L. natalensis* was the dominant species followed by *B. pfeifferi* in river habitat. *L. natalensis* accounted for 16.45% of the snail collection and encountered 29.2% of the surveyed sites with prevalence of 69.6%, 24.7% and 2.1% in wetlands, rivers and irrigation ditches, respectively. The irrigation canals and wetland structures are snail-breeding sites [29]. *Bulinus globosus* occurred in the same habitats except in irrigation ditches. *B. pfeifferi* was collected in lakes, wetlands and rivers. The highest prevalence of this snail species was recorded from rivers. The study by Salawu & Odaibo [30] also indicted that B*. pfeifferi*, *B .globosus* and *L. natalensis* were prevalent in the river habitat. However, in this study, least common snail species such as *L. truncatula, B. sudanica and Physa spps* were encountered in less than 10% of the surveyed sites in rivers, lakes and wetland habitats, respectively. De Kock et al [31] reported that *L. truncatula* was mostly recorded from swamp habitat.

This study tried to investigate the relationship between flow velocity and land use type. This study showed that the flow velocity of water was highest in Woodland areas while the minimum mean value was recorded in Grassland areas. On the other hand the highest mean value of water depth recorded in Settlement areas whereas canopy cover and vegetation cover were comparatively higher in Forest area. Except for water-depth all the habitat factors were found to have significant association with the land-use types. Depth of water has very little direct influence on the molluscan fauna [33]. Study by Lydig [34] showed that both *B. pfeifferi* and *L. natalensis* were significantly affected by vegetation. Further, this study showed that land-use types is significantly associated with flow velocity and canopy cover . Similarly this study shows, land-use types and vegetation cover are significantly associated with flow velocity. Study of Abate and Lemenih [5] confirmed that, the rapid increase in cultivated land and built up area is associated with decreasing trend in vegetation cover of certain area. This also agreed by Brasher *et al* [35] , rapid increasing urbanization has resulted in stream habitat alteration characteristics at urban and agriculture land-use areas with markedly different from forested areas.

From this study, the mean dissolved oxygen saturation (DO %) is highest in Forest (M=83%), whereas lowest in settlement area (M=49.5%). As indicated by Qiu *et al* [38], forest was positively associated with dissolved oxygen .The water dissolved oxygen concentration (DO mg/L) was highest in Settlement areas (21.2 mg/L) and least in Shrubland (3.87 mg/L) . Biochemical oxygen demand was highest (14.11 mg/L) in Shrubland while the least mean value was recorded (11.59 mg/L) in Settlement area. Reduced dissolved oxygen and increased biological oxygen demand in the water column is due to reduced photosynthetic activity as a result of mortality of algae from anthropogenic cause high demand of BOD [36].

This study showed nitrate concentration (NO_3^- mg/L) of water was highest in Settlement area while the least mean value was recorded from Forest area. Qiu *et al* [36] concluded that settlement land-use was strongly associated with nitrate concentrations. This study showed significant association between land-use types and NO_3^- concentration. Yirenya-Tawiah *et al* [37] reported the nitrate concentration level of the Kpong head pond in Ghana was varied between 0.9 mg/L and 1.4 mg/L.

The current study assessed the distribution of medically important freshwater snails *Lymnaea* spp. and *Biomphalari*a spp. The snail species such as *L. natalensis* were found in 38 sites of the total sampling sites in all land-use types while *L. truncatula* was collected from seven sampling sites of Omo-Gibe river basin in all land-use types except in Forest and Shrubs land. This was supported by Sangwan et al [39] that Lymnaea species is prevalence at Settlements areas. Moreover, from this study, *B. pfefferi* was found frequently from Farmland followed by Settlement areas. This snail species was found in fifty-one sampling sites of all land-use types except at Woodland but not found at seventy-nine sampling sites of all the land-use types in Omo-Gibe river basin. The other freshwater snail species, *B. globosus* was found numerously at eight sites of Forest followed by five sites at the Settlement land-use type. Among these different snail species the majority, 54 % were collected from Settlement followed by Farmland (20.4 %), land-use type. This was agreed by the study of Qiu et al [38] that agricultural land or farmland use has positive relationship to snail distribution. In addition, *P. acuta*, *L. natalensis*, *B. pfeifferi*, and *B. globosus* snail species were collected at nine of the ten urban stations in Douala, Cameroon [40]. However, the distribution of these snail intermediate hosts was significant to land-use types in Omo-Gibe river basin. This is due to anthropogenic activities that can cause land use change in facilitating substrate, suitable habitat condition fast current water that displaces the freshwater snail species [41]. This study shows that *L.natalensis* was highest at the Settlement followed by *P. acuta*. Opisa et al [42] collected *B. pfeifferi* and *B. globosus* in different habitats of Lake Victoria, at settlements. This is because of the sites are along lakeshore and inland environmental condition and ecological variation [42]. *L. truncatula* and *Physa spps* were observed at Farmland in this study. The distribution of *B. pfefferi* at Farmland is followed by *B. globosus* and *B. sudanica* at Forest land-use. Camara et al [43] agreed the appearance of freshwater snails in the river basin reflected eutrophic process due to anthropogenic activities. In addition, Tchakonte et al [40] explained, the distribution of freshwater snails in river basin reflected the pollution status of its urban streams due to anthropogenic activities.

This study assesses the distribution of cercaria infected snails and trematode cercaria infection rate. The study shows that some of medically important freshwater snails are found infected by cercaria.. Cercariae positive freshwater snail species were insignificantly distributed at eleven sites in relation to land-use types such as Settlement, Grassland, Farmland and Shrubs land in Omo-Gibe river basin. The majority of infected snails observed at Farmland and Grassland. In this study, *B. pfeifferi* is found infected by different type of cercariae. Marie *et al* [44] reported that *B. pfeifferi* infection was recorded (14.7%) from snails collected with respect to irrigation canals. During the examination *B.sudanica* infection by trematode cercariae was not observed. Similar studies of Marie *et al* [44] showed that *B.sudanica* infection was not observed. This is due to resistance of snails to trematode infections and the prevalence of larval trematode infections is dependent on snail numbers [44]. Further, in this study, infection of *B.globosus* and *L.natalensis* by more than one and same type of cercariae was observed. According to Devkota et al [45] the degree of infection may vary in snails of the same species from one location to another, even though the areas might be apparently similar and geographically proximate to each other. Similarly, Jayawardena [46] indicated the trematode infected snails and variation in infection can easily arise as a consequence of the distribution of second intermediate and final hosts and/or habitat characteristics which affect the risk of infection.

Conclusion

The findings of this study revealed that seven species of freshwater snail intermediate hosts which included: *B. pfefferi*, *B. sudanica*, *B. globosus*, *L. natalensis*, *L. truncatula*, *Physa acuta and Physa Spps* were recorded in the study area. *Biomphalaria pfeifferi* was predominant in all habitats with highest frequency from rivers. *Bulinus globosus* was recorded at similar habitats except in irrigation ditches. The study mapped the distribution of snails in relation to land-use types. The majority of snail species were collected from Farmland and Settlement. This could be attributed to occasional flood to water bodies that can carry eggs or adults of snails to new locations, anthropogenic activities, available substrates and micro habitat characteristics.

This study s also shows cercariae infected freshwater snail species such as *Lymnea spp.*, *B. pfefferi* and *B. globosus* from different land-use types. Higher cercariae infection was observed from Farmland and Grassland snails. Mainly *B. pfeifferi* was the most infected snail by different type of cercariae.

Declarations

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Authors contribution KD, EJ and STM conceived the main idea of the study, collected and analyzed the data and drafted the manuscript. **BM and YA** collected the data and contributed to writing the paper. **DY and ZM** critically reviewed the manuscript. All authors read and approved the final manuscript.

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Availability of data and materials

All data generated or analyzed during this study are available from corresponding author up on request

Ethics approval and consent to participate

Wild fresh water snails used for this study and collected from different type of land use after getting landowner' verbal consent. The protocol was reviewed and approved by the Institutional Review Board (IRB) of Jimma University Institute of Health.

Consent for publication

Not applicable

Computing interest

The authors declare that they have no competing interests

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Figures

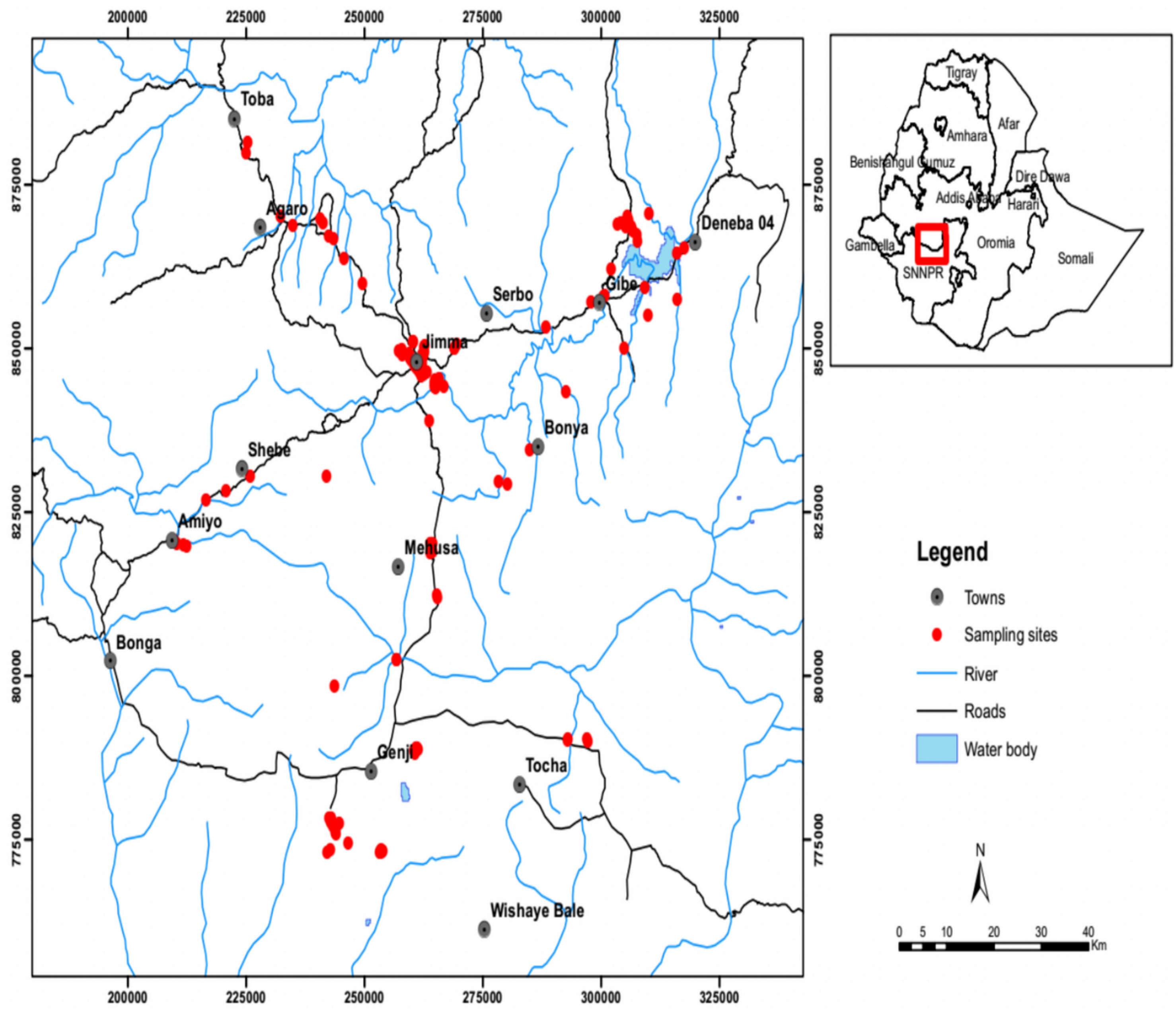

Figure 1

Map of the sampling sites in Omo-Gibe River basin, Ethiopia.

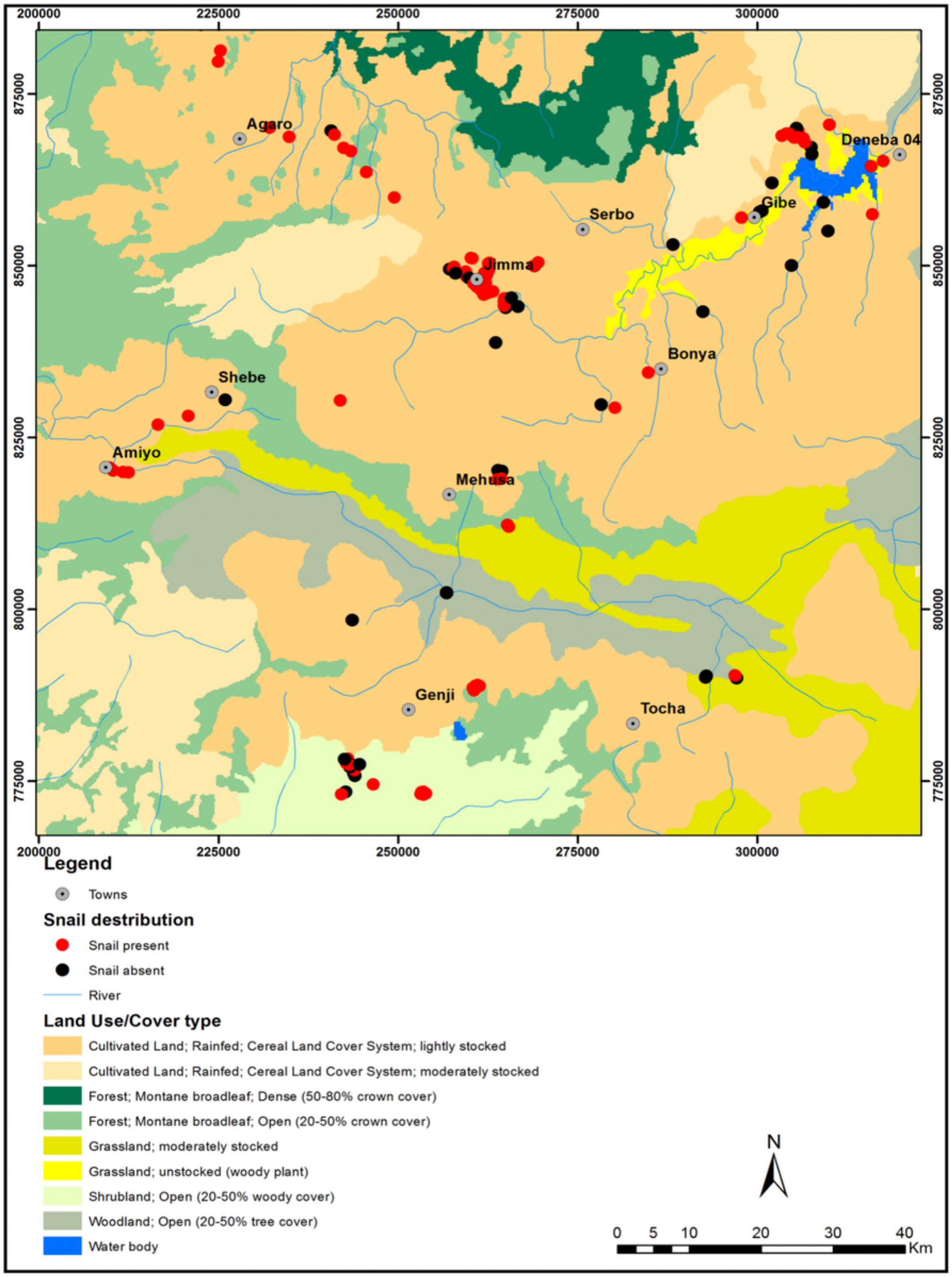

Figure 2

Map of freshwater snail distribution in different land-use type in Omo-Gibe river basin, Ethiopia. (* red dots show sites positive for snails and black dot show sites negative for snails)

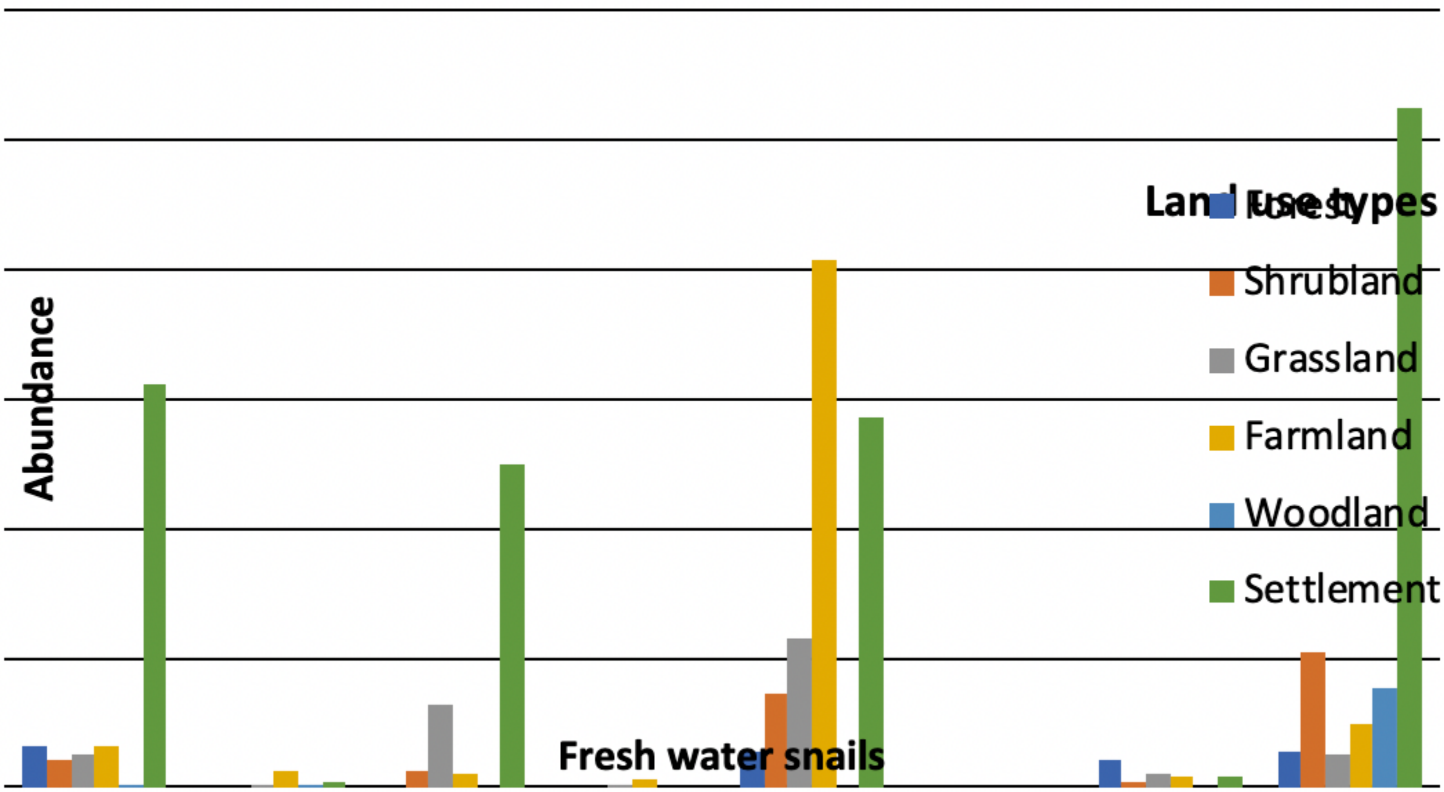

Figure 3

Abundance of freshwater snails by land-use type in Omo-Gibe river basin, Ethiopia.

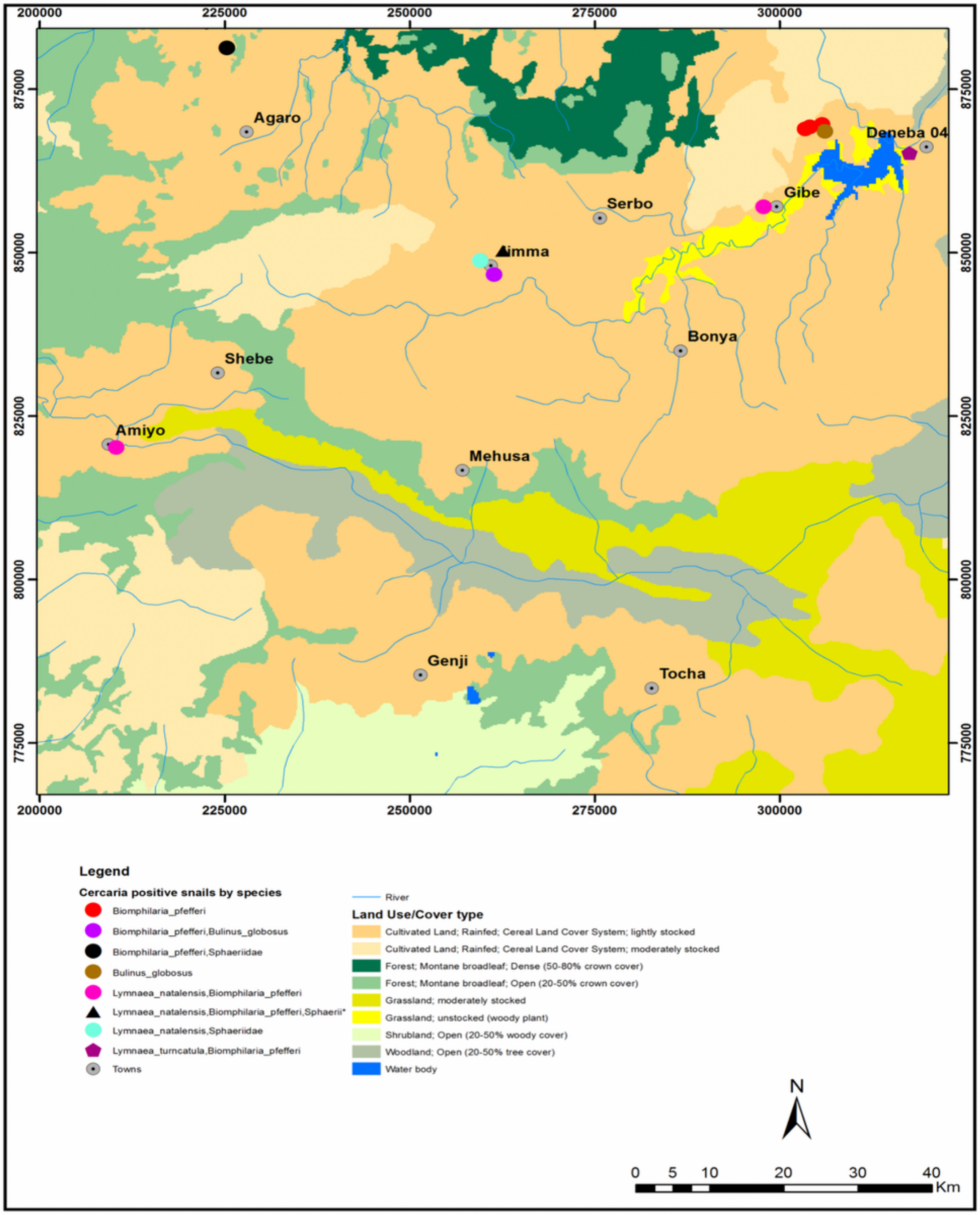

Figure 4

Distribution of cercariae positive freshwater snails in different land use type in Omo-Gibe river basin, Ethiopia.